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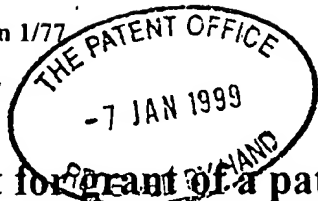
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2. Patent application number

9900296.6

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3. Full name, address and postcode of the or of each applicant (underline all surnames)

Mars U.K. Limited
3D Dundee Road
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Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of incorporation

United Kingdom

7475973001

4. Title of the invention

Body Fat Measurement System

5. Full name, address and postcode in the United Kingdom to which all correspondence relating to this form and translation should be sent

Reddie & Grose
16 Theobalds Road
LONDON
WC1X 8PL

Patents ADP number (if you know it)

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Priority application
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Date of filing
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Kingdom

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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
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Description	9
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Drawing(s)	3 <i>13</i>

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Priority documents	-
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Date

Ioddie & Grace

7 January 1999

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IAN M LOVELESS
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BODY FAT MEASUREMENT SYSTEM

The present invention relates to a system for measurement of the percentage of body fat by weight of four legged mammals, in particular domestic cats.

5 Obesity is the most common form of malnutrition in cats, however, the links between obesity and the risk of clinical conditions are not well understood. This is primarily because there is no accepted method for defining obesity or measuring body fat in cats.

10 The body mass index (BMI), which is based only upon measurements of body weight and height, allows objective measurement available for humans. The main techniques available to veterinary practitioners are subjective ones such as the Body Condition Score (BCS) system produced by
15 Latflamme.

We have appreciated the requirement for a simple, objective system for determining the percentage body fat by weight of four legged mammals, in particular cats. In particular, we have appreciated that the system should be
20 reliable and capable of implementation in both technologically simple and complex embodiments. The system should also be easy for inexperienced operators to use.

Accordingly, there is provided a system for measuring the
25 percentage body fat of a four legged mammal, comprising:

- means for measuring a first body dimension having a high correlation with percentage body fat;
- means for measuring a second body dimension having a low correlation with percentage body fat; and

- a look-up table comprising a first storage area for storing entries of the first body dimension, a second storage area for storing entries of the second body dimension and an output area for indicating the percentage body fat determined from a relationship between the first and second body measurements.

The system of the invention has the advantages of being simple to operate, reliable and capable of implementation as a low technological manual system, or a more sophisticated computerised implementation.

In a preferred embodiment the first body dimension is the circumference of the ribcage. This measurement has been appreciated, through experimentation, to be highly correlated to a four legged mammal's percentage body fat. In the embodiment, the second body dimension is a leg index measurement, preferably the distance between the Patella (knee) and the calcaneal tuber (hock) with the leg flexed of the hind limb which, we have appreciated, has a low correlation with percentage body fat. The use of the body measurement of high correlation with body fat and one with low correlation increases the accuracy of the determined percentage body fat.

A system embodying the invention will now be described with reference to the accompanying figures in which:-

Figure 1- is a diagrammatic representation of a system embodying the invention;

Figure 2- is a diagrammatic representation of a first look-up table for use in the system of Figure 1; and

Figure 3- is a diagrammatic representation of a second look-up table for use in the system of Figure 1.

5 The embodiment shown in Figure 1 may be either manually operated, or a computerised system. A first measurement device 10 and a second measurement device 12 are provided to take measurements of, respectively, the ribcage circumference and the leg index measurement [LIM] to provide the results to the look-up table 18. In a
10 computerised embodiment, the measurement devices 10, 12 would provide measurement signals to a computer, storing therein in first, second and output storage areas respectively, ribcage and LIM, and corresponding fat percentage indications. These are shown as storage and
15 determination functions 14 in Figure 1. The results are displayed as an output display 18. The determination algorithm (described later) could be coded in any simple computer language, and is within the common general knowledge of the skilled person, and need not be described
20 here.

A manual representation of the look-up table 18 is shown in Figures 2 and 3. There is shown a first storage area 20, storing first body dimensions (ribcage) measurements, and a second storage area 22, storing second body
25 dimensions (LIM). An output storage area 24 stores an indication of the percentage body fat of a domestic cat as a relationship of the first and second dimensions. The indication is under, normal or overweight in Figure 2. In figure 3, the indication is given as a percentage number.

30 In appreciating that the system embodying the invention provides a uniquely robust and reliable system for determining the percentage body fat of a cat, a number of experiments were undertaken, as will now be described.

To establish the correlation between body condition score (BCS) and body composition (% body fat) as measured using Dual Energy X-Ray Absorptiometry (DXA), and to compare zoometric measurements with estimates of body condition score and % body fat using DXA, in order to develop a simple objective method of determining body condition, the following method was adopted.

Zoometric measurements and estimates of BCS (body condition score) and body composition (using DXA), were taken from 60 domestic, short-haired cats, housed indoors. All measurements were taken between 03/03/97 and 22/05/97, by a single observer. In the study, 28 males (all neutered) and 32 females (of which 8 were entire) were used. The average age of the females was 4.92 years and males 3.94 years. The body weights of entire female cats ranged from 2.34 to 4.1 Kg, the neutered female cats from 2.84 to 6.6 Kg and the males 4.2 to 8.18 Kg. Cats had been fed a variety of diets at the time measurements were taken.

The following zoometric measurements were taken from each cat. These were selected because they were considered to represent body condition or had been found from human data to be potentially useful.

Height: The distance between the ground and the Withers (the top of the shoulder blade or scapula) as measured using a measuring stick. This is a wooden metre ruler with a fixed base, perpendicular to the rule and a sliding wooden bar.

Chest Dept: The vertical distance from the top of the capula to the bottom of the chest, using a measuring stick.

- Girth: The circumference at the point of the 4th lumbar vertebrae, just behind the last rib, using a measuring tape.
- 5 Ribcage: The circumference at the point of the 9th rib (5 ribs from the posterior end of the ribcage), using a tape measure.
- Length: The horizontal distance from the breast-bone (manubrium) to the thigh (perineum), using a measuring stick.
- 10 Elbow: Measured on the left elbow using a calliper. It is the distance between the lateral epicondyle of the humerus and the medial epicondyle of the humerus.
- 15 Front Long Bone: The length of the humerus, from the proximal ulnar epiphysis to the distal radial epiphysis, using a measuring stick.
- 20 Leg index measurement [LIM]: The distance between the Patella (knee) and the calcaneal tuber (hock) with the leg flexed.

25 All measurements were taken from the left hand side of the cat whilst it was standing with its legs perpendicular to the ground and with its head up and looking forward. Cats were weighed prior to taking the measurements, which were taken in a fasted state. Five replicates of each measurement were taken on the same day.

30 The Purina Body Condition Score (Laflamme, 1998) was used as a subjective assessment of body condition. The cat was given a score on a nine point scale, which ranged from 1

for emaciated to 9 for morbidly/grossly obese, although experienced assessors are able to grade cats to 0.5 of a scale. A cat with a BCS score of 5 was considered to be ideal. This scoring system was based on a variety of features, which included palpability of the ribs, presence of a discernible waist and abdominal tuck, and evidence of bony prominence and fat deposits on the lumbar area and base of the tail.

The percentage body fat was measured by dual energy X-ray absorptiometry, using a Hologic QDR 1000/W densitometer. They were anaesthetised using Domitor (0.1ml/Kg) and recovery induced with Antisepen.

Eight inexperienced observers each made an estimate of BCS and took their replicates of each zoometric measurement on the same seven cats, in order to test for inter-observer variability in predicting body condition.

Each Zoometric measurement was compared with % body fat because this represented the most objective estimate of body composition. The most significant correlation with % body fat was for ribcage. This factor is more likely to be affected by an increase in body weight or obesity. It may therefore be considered to provide an estimate of % body fat, or 'fatness'. The lowest correlation's with % body fat were found for the LIM and height measurements ($r^2 < 15.4\%$). This is a low correlation. These may therefore be considered to be measurements of stature which are relatively unaffected by changes in % body fat.

We appreciated that a system could be devised using this data to provide a simple system for measuring the percentage body fat of cats. The formula that describes

the most variation in percentage body fat and is biologically meaningful is:

$$Fat = \left[\frac{\left(\frac{Ribcage}{0.7067} - LIM \right)}{0.9156} \right] - LIM$$

The mean, standard deviation and coefficient of variation were determined for each of the 60 cats from the five replicates made for each zoometric measurement by the experienced observer. The mean and median coefficient of variation (CV) for each zoometric measurement was less than 10% suggesting that the intra-observer repeatability was low and that a single measurement would be needed in future (see table below).

CV for each zoometric measurement made by a single experienced assessor.

	Coefficient Of Variation (%)			
	Mean	Median	Min	Max
Weight	2.30	1.19	0	12.78
Girth	1.96	1.57	0.27	6.74
Ribcage	3.03	2.6	0.5	15.57
Height	1.49	0.93	0.18	8.94
Chest Dept	3.54	3.34	1.36	9.62
Length	2.37	2.15	0.22	6.26
Elbow	4.28	4.35	0	9.56
Front Long Bone	2.11	1.77	0	5.26
LIM	2.5	2.16	0.33	8.19

The cats included in this study encompassed a wide range of body composition and age, but were of a single population of related genetic domestic short-haired stock. They may therefore form a representative sub-sample of the domestic cat population in general.

BCS was significantly correlated with % body fat, when measured using DXA ($r^2 = 73.4\%$, $p < 0.01$) and gave a reasonable prediction of % fat. However, the correlation was lower than that reported by Laflamme (1998) where $r^2 = 83.5\%$, although 48 cats were used in this study, of which only 4 individuals had a BCS less than 5. Using the BCS system in this study, cats which were of ideal body condition (BCS = 5) had between 15 and 30% body fat. Cats which were considered to be underweight (BCS < 5), were less than 20% fat and those which were overweight (BCS > 6) were more than 30% fat. Whilst these data sets are relatively small (underweight group = 7 cats, ideal = 8 cats) it gives an indication of the cut off points that might be used for these major categories of % body fat for cats. The largest discrepancy between % body fat and BCS occurred for those animals considered to have a BCS between 5 and 6. This may indicate the problems of correctly identifying animals of 'ideal' condition when animals differed greatly in stature. Animal stature, particularly of very large or small cats was considered to be a determining factor in the large variation of BCS assigned to individual cats by different observers, resulting in a relatively high CV of 15.3%. It would appear that the BCS type of assessment is truly subjective.

By comparison zoometric measurements, and ribcage in particular ($r^2 = 82.9\%$) were more highly correlated with % body fat than the BCS system. This is a high correlation.

The high level of repeatability for the ribcage and LIM
measurements of cats and the high correlation between the
zoometric model and % body fat suggests that this
objective measurement is a more appropriate tool for
5 determining body composition of cats than BCS. In
addition it is also non-invasive, requires little training
to achieve an acceptable level of repeatability and
requires only a metric tape measure. This makes this
method available for all veterinary practitioners and cat
10 owners.

CLAIMS

1. A system for measuring the percentage body fat of a four legged mammal, comprising:
 - means for measuring a first body dimension having a high correlation with percentage body fat;
 - means for measuring a second body dimension having a low correlation with percentage body fat; and
 - a look-up table comprising a first storage area for storing therein entries of the first body dimension, a second storage area storing therein entries of the second body dimension and an output storage area storing an indication of the percentage body fat determined from a relationship between the first and second body measurements.
2. A system according to Claim 1, wherein the first body measurement is the circumference of the ribcage, taken at the 9th rib.
3. A system according to Claim 1 or Claim 2, wherein the second body measurement is a leg index measurement, which is the length of the hind limb measured between the patella (knee) and the calcaneal tuber (hock).
4. A system according to any preceding claim, wherein the output storage area provides an indication of whether the mammal is under, normal or overweight.
5. A system according to any preceding claim, wherein the output storage area provides a numerical percentage body fat.

6. A system according to any preceding claim, wherein the relationship between the percentage body fat and first and second body dimensions is given by the equation:-

$$PercentageBodyFat = \left[\frac{\left(\frac{R}{C_1} - L \right)}{C_2} \right] - L$$

5 where R = ribcage circumference
 L = leg index measurement
 C1 = constant
 C2 = constant

7. A lookup table for use in the system of any
10 proceeding claim, comprising:
- a first storage area storing therein entries of the first body dimension;
 - a second storage area storing therein entries of the second body dimension; and
 - 15 - an output storage area storing an indication of percentage body fat determined from a relationship between the first and second body measurements.
8. A system substantially as herein described and with reference to the accompanying figures.
- 20 9. A lookup table substantially as herein described and with reference to the accompanying figures.

Abstract

BODY FAT MEASUREMENT SYSTEM

5 A body fat measurement system for mammals includes means
for measuring first and second body dimensions having a
high correlation with body fat and low correlation
respectively. A lookup table provides an output of the
percentage body fat on input of the first and second
dimensions.

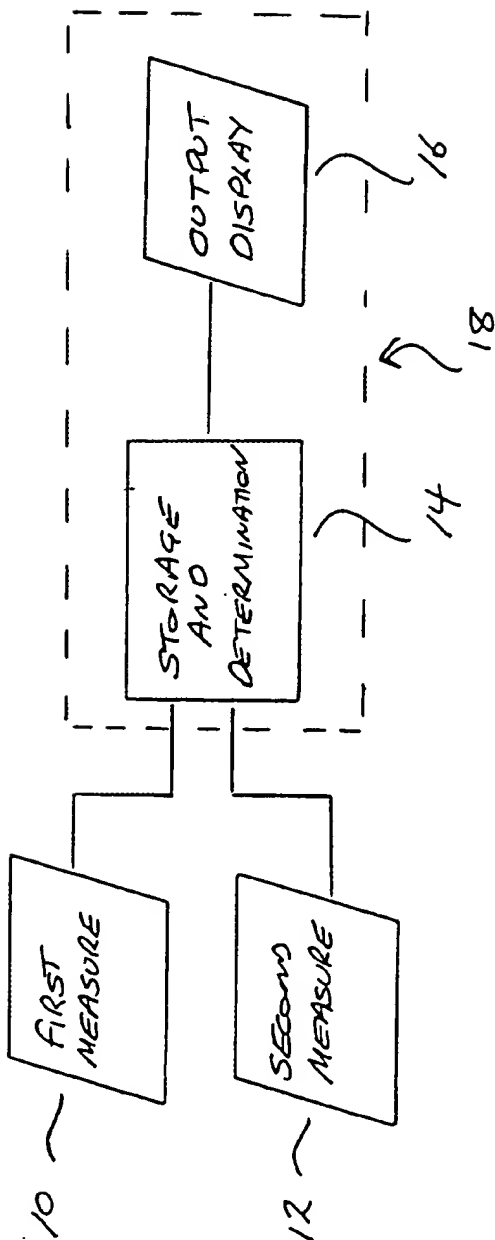


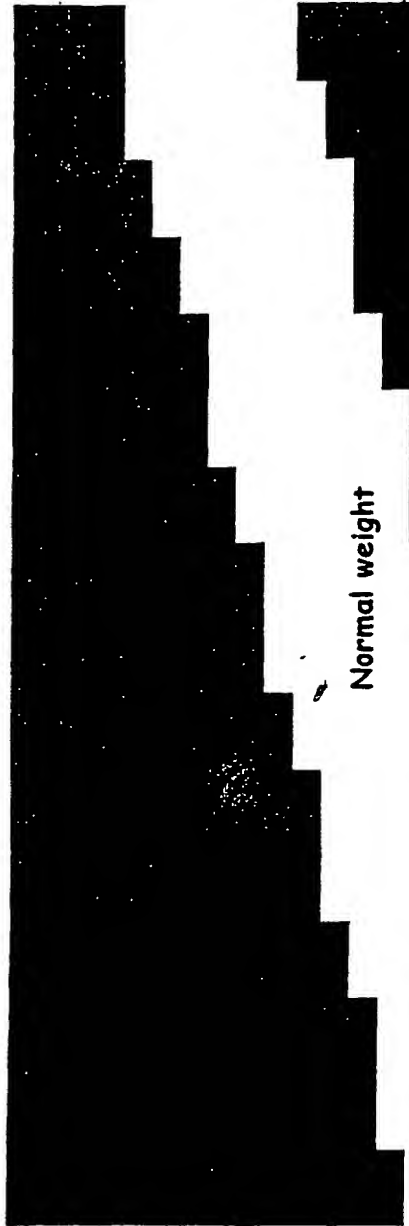
Fig 1

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Rib cage (cm)

18 →

20 ~



Normal weight

24

2/3

10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Back longbone (cm)

22

fig 2

Percentage bodyfat content

60
58
56
54
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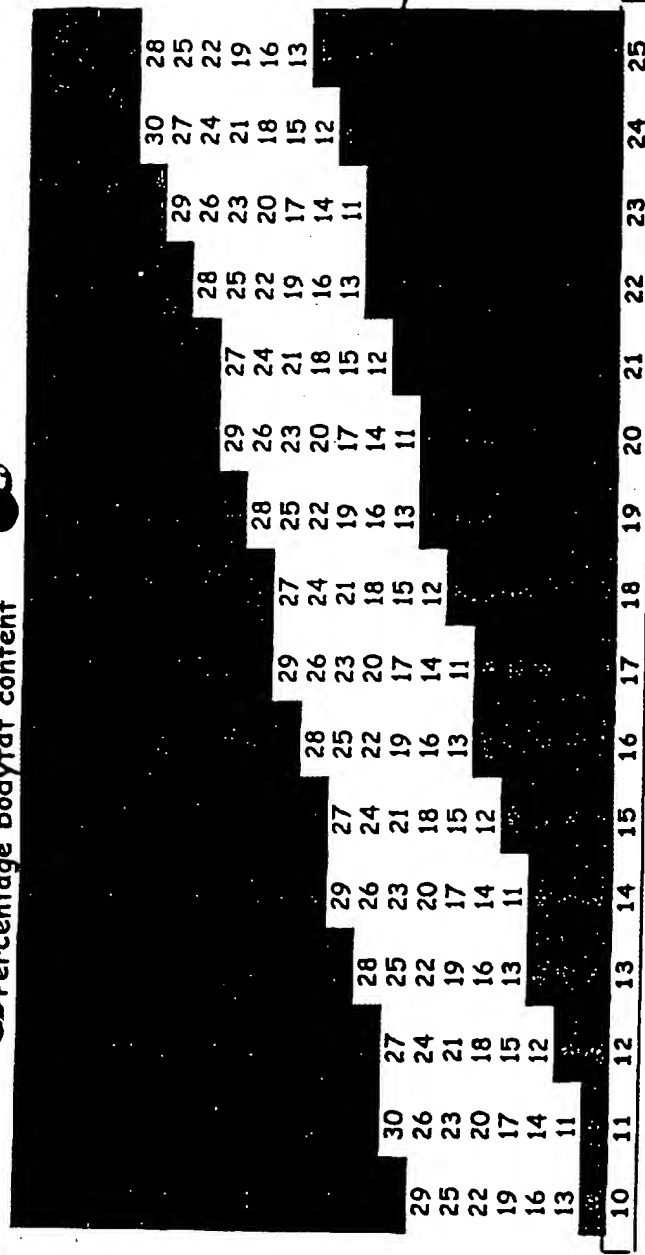
Rib cage (cm)

18 →

20 ~

24

3/3



Back langbone (cm)

Key

Normal weight
Over weight
Under weight

Fig 3

22

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